FREDERICK UNIVERSITY
Department of Mechanical Engineering

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| PROGRAMME: | «BSc in MECHANICAL ENGINEERING» |
| COURSE: | Machine Elements I - AMEM 316 (AUTO308) |
| ACADEMIC YEAR: | 2013-14 |
| INSTRUCTOR: | Dr. Antonios Lontos |
| DATE: | 11/01/2013 |

# ASSIGNMENT No 2:
# DESIGN OF FASTENERS – BOLTED CONNECTIONS – WELDED JOINTS


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**Reg. Num.: 1212**


**NICOSIA - CYPRUS**

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# FREDERICK UNIVERSITY CYPRUS
## DEPARTMENT OF MECHANICAL ENGINEERING

**Subject:** Machine Elements AMEM 316 – AUTO 308
**Academic Year:** 2010 – 11 (Fall Semester)
**Instructor:** Dr. Antonios Lontos

## ASSIGNMENT No 2:
### DESIGN OF FASTENERS – BOLTED CONNECTIONS – WELDED JOINTS

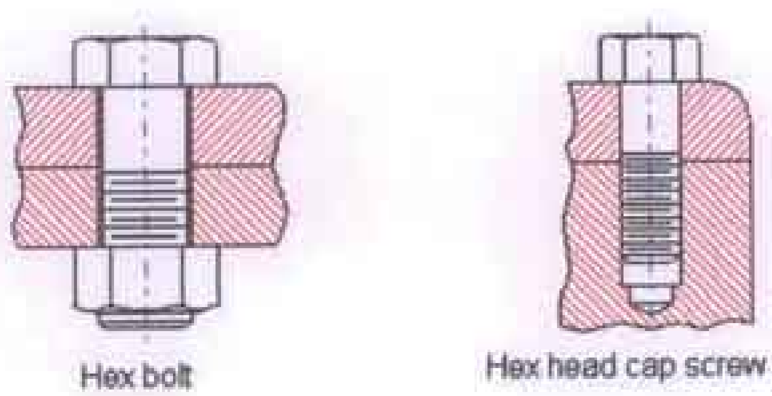
**INFORMATION ABOUT THE ASSIGNMENT**

The followings are the input data for MDESIGN software.

1. Using the appropriate equations fill the result tables. Give in detail the calculating procedure by giving all the equations in every step.
2. For each case design the front view, one detailed cross section and a real 3D drawing.
3. For each case give two different websites using pictures and any other useful information.
4. $F_1$ = (a) 10248 N, $F_2$ = (b)14973 N, $F_3$ = (c) 6552 N

## 1. FASTENERS

Bolt and Screw




### Input Data:

| | | |
|---|---|---|
| Clamping force | F1 = | (a) 10248 N |
| Number of bolts | n = | 4 |
| Demand factor | k = | 65 % |
| Constant dependent on the lubrication present | k1 = | 0.25 |

## Calculations:

**Allowable stress**

$$\sigma_a = \kappa * [\sigma] = 0.65 \times 420 = 273MP_a$$

**Required tensile stress area**

$$P = \frac{F}{n} = \frac{10248}{4} = 2562N$$

$$A_t = \frac{P}{\sigma_a} = \frac{2562}{273} = 9.38mm^2$$

**Basic major diameter**

$$A = A_t = \frac{\pi * D^2}{4} \rightarrow D^2 = \frac{4 * A}{\pi}$$

$$D = \sqrt{\frac{4 * A}{\pi}} = \sqrt{\frac{4 * 9.38}{\pi}} = \sqrt{\frac{37.52}{\pi}} = \sqrt{11.94} = 3.46mm$$

**Tensile stress area**

From table coarse and fine thread dimensions –metric **Figure 10-a**
D= 4 mm → Tensile stess area = 8.78 mm²

**Required tightening torque**

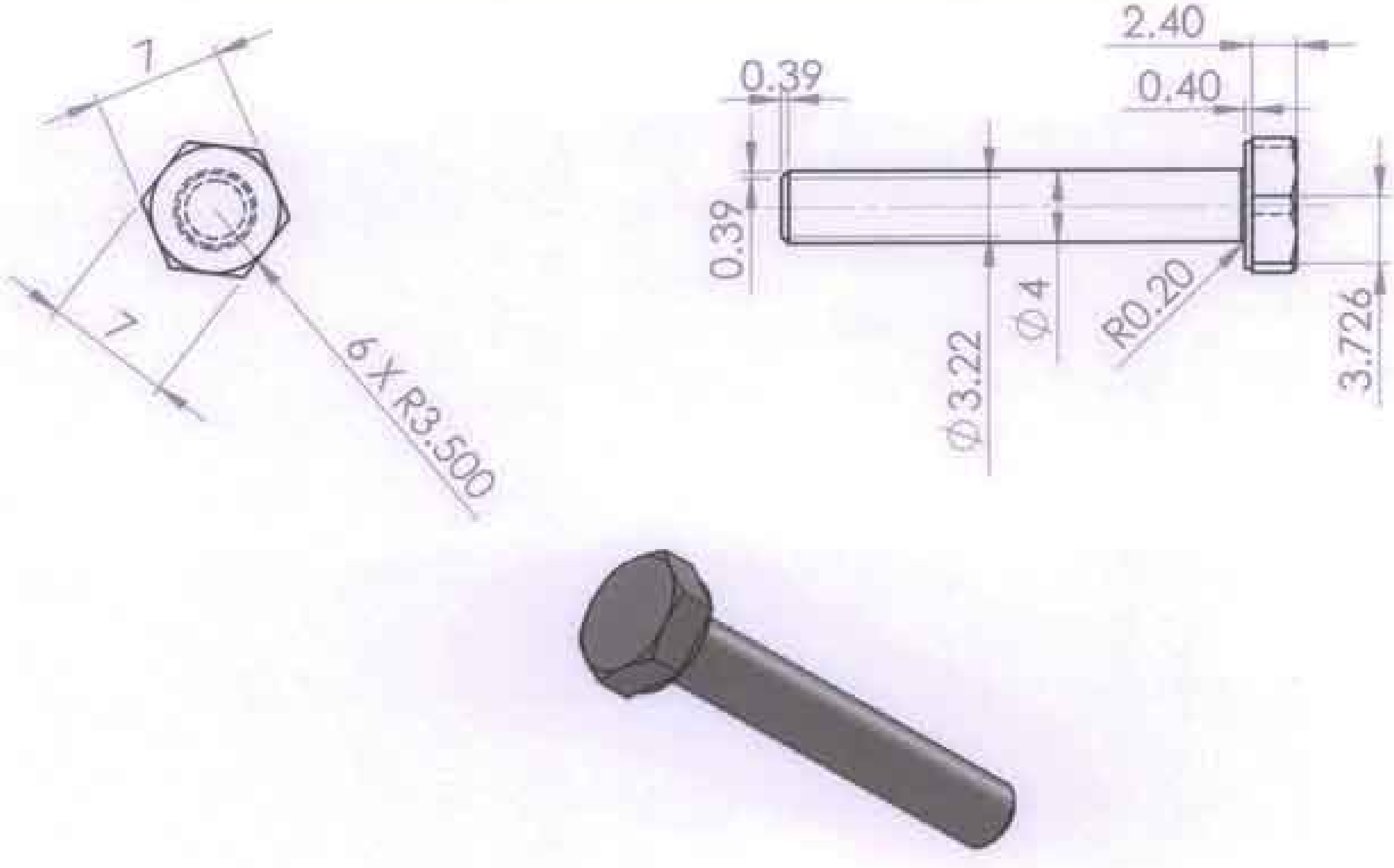
$$T = \kappa_1 * D * P = 0.25 \times 4 \times 2562 = 2562N * mm$$

## Results:

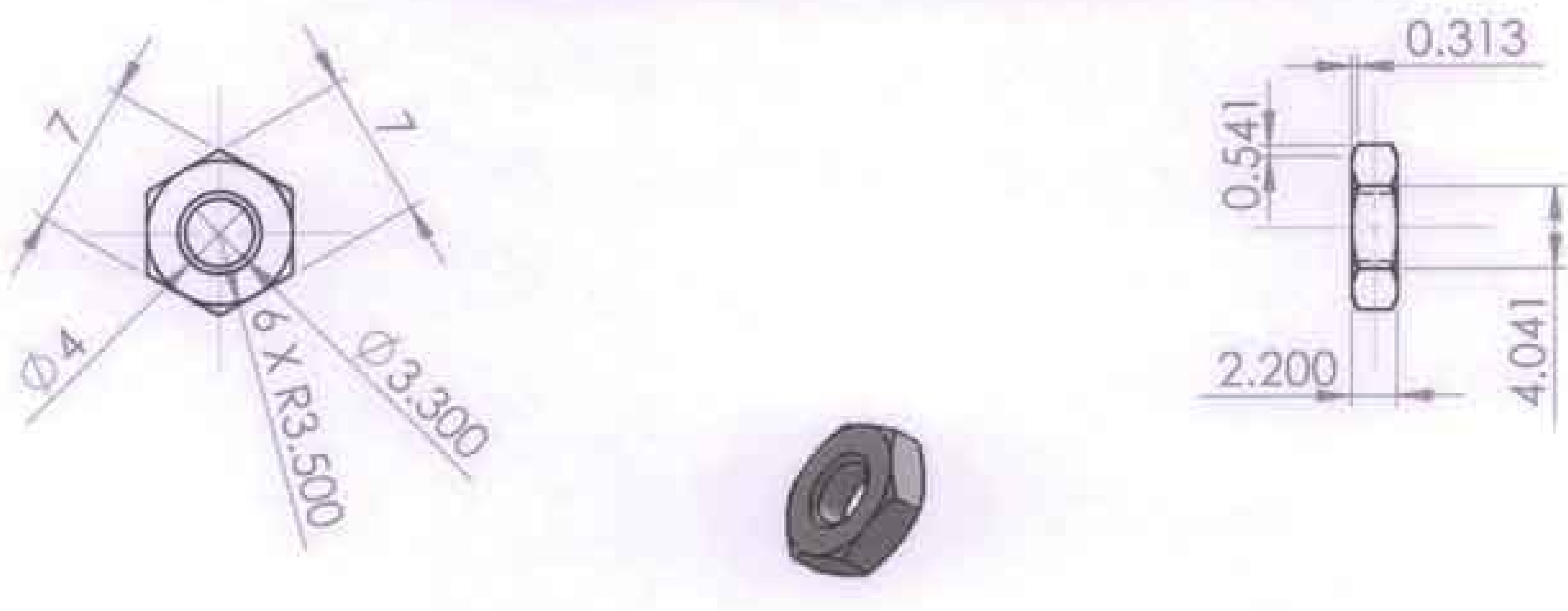
| | | | |
|---|---|---|---|
| SAE steel grade | = | 2 | |
| Proof strength | [σ]= | 420 | MPa |
| Allowable stress | σa= | 273 | MPa |
| Required tensile stress area | At= | 9.38 | mm² |
| Thread type | 12-24 UNC | | |
| Basic major diameter | D= | 3.46→4 | mm |
| Tensile stress area | At(table)= | 8.78 | mm² |
| Required tightening torque | T= | 2562 | N*mm |

Finally I chose Basic major diameter D= 4mm = M4 for more safety .

## HEX BOLT CRADE AB-ISO( ISO 4014-M4X25X14-C )




## HEX THIN NUT CHAMFERED GRADE AB-ISO (HEXAGON THIN NUT ISO-4035-M4-C)




## PLAIN WASHER CLEVIS PIN GRADE AB-ISO (WASHER ISO 8738-4 )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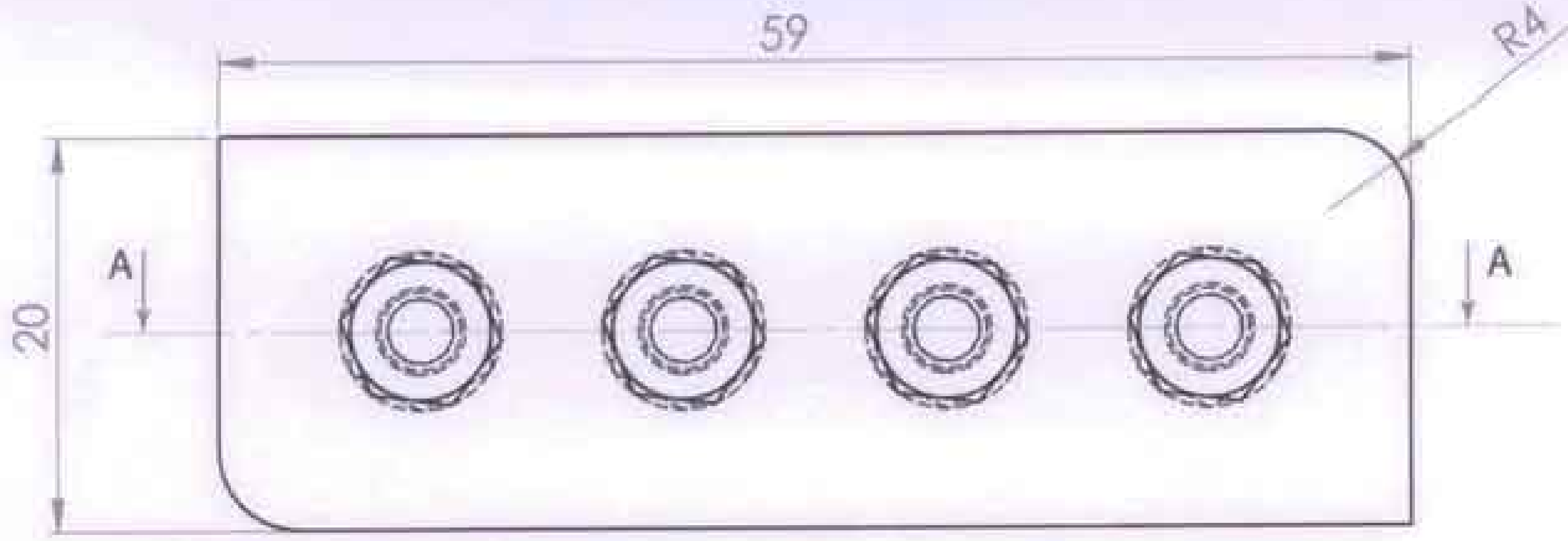
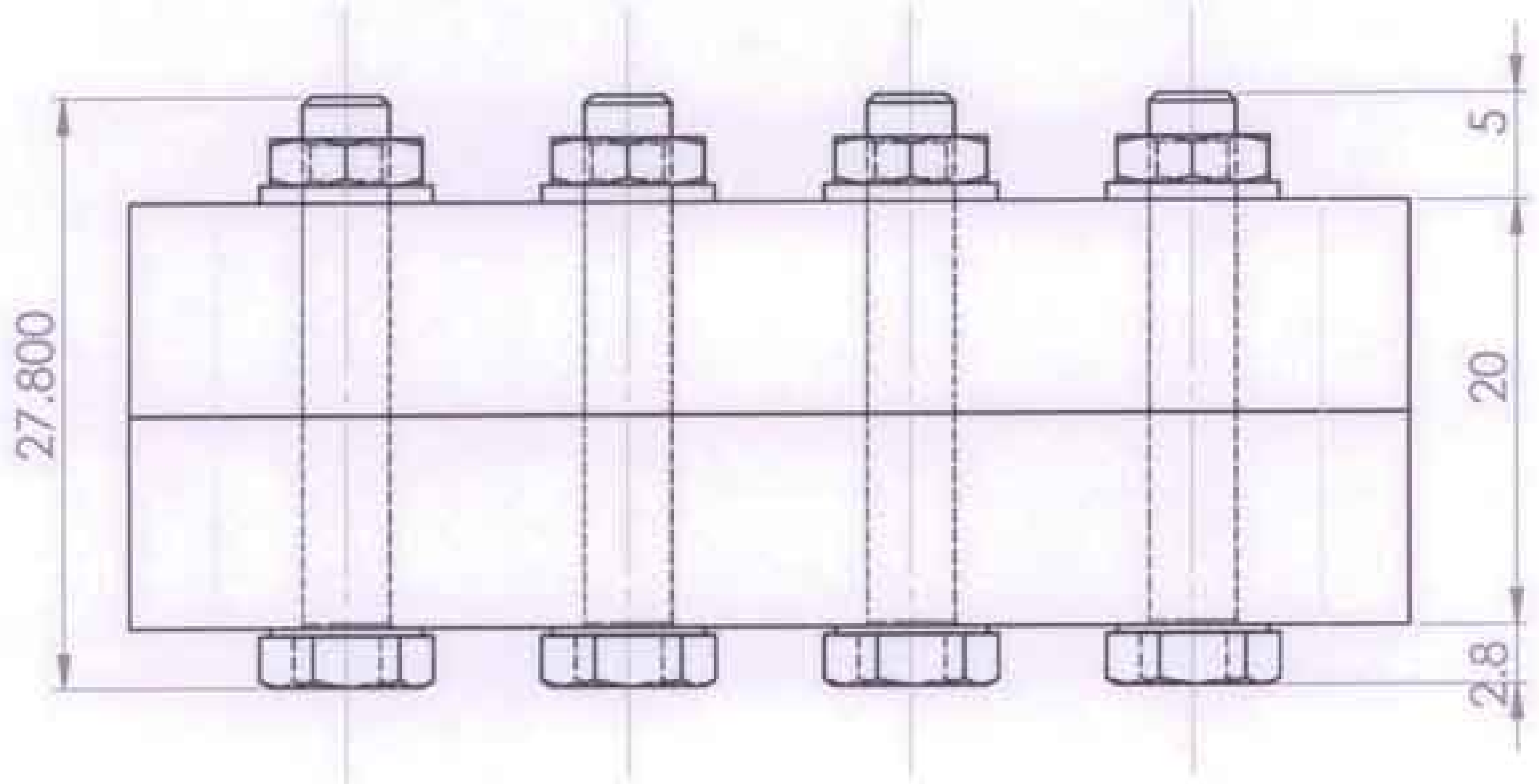
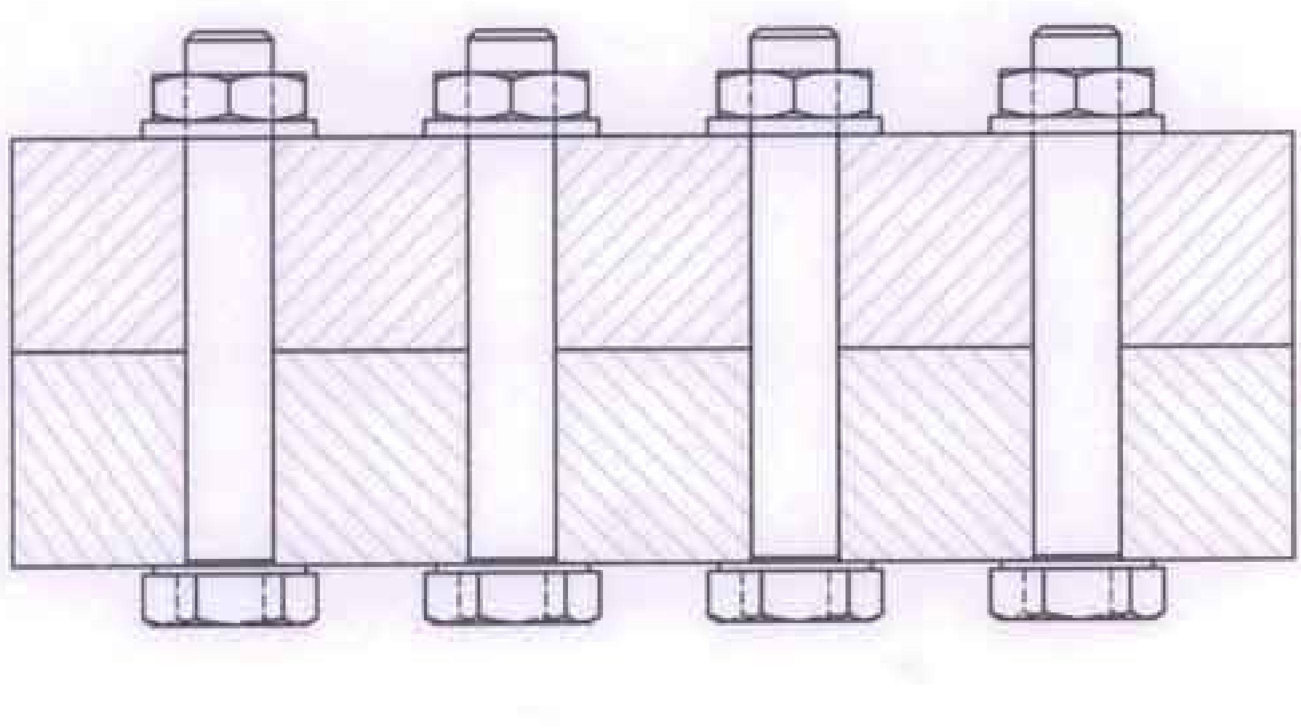
| | 1.FASTENERS | SCALE : 2:1 | 3 |




CROSS SECTION A-A



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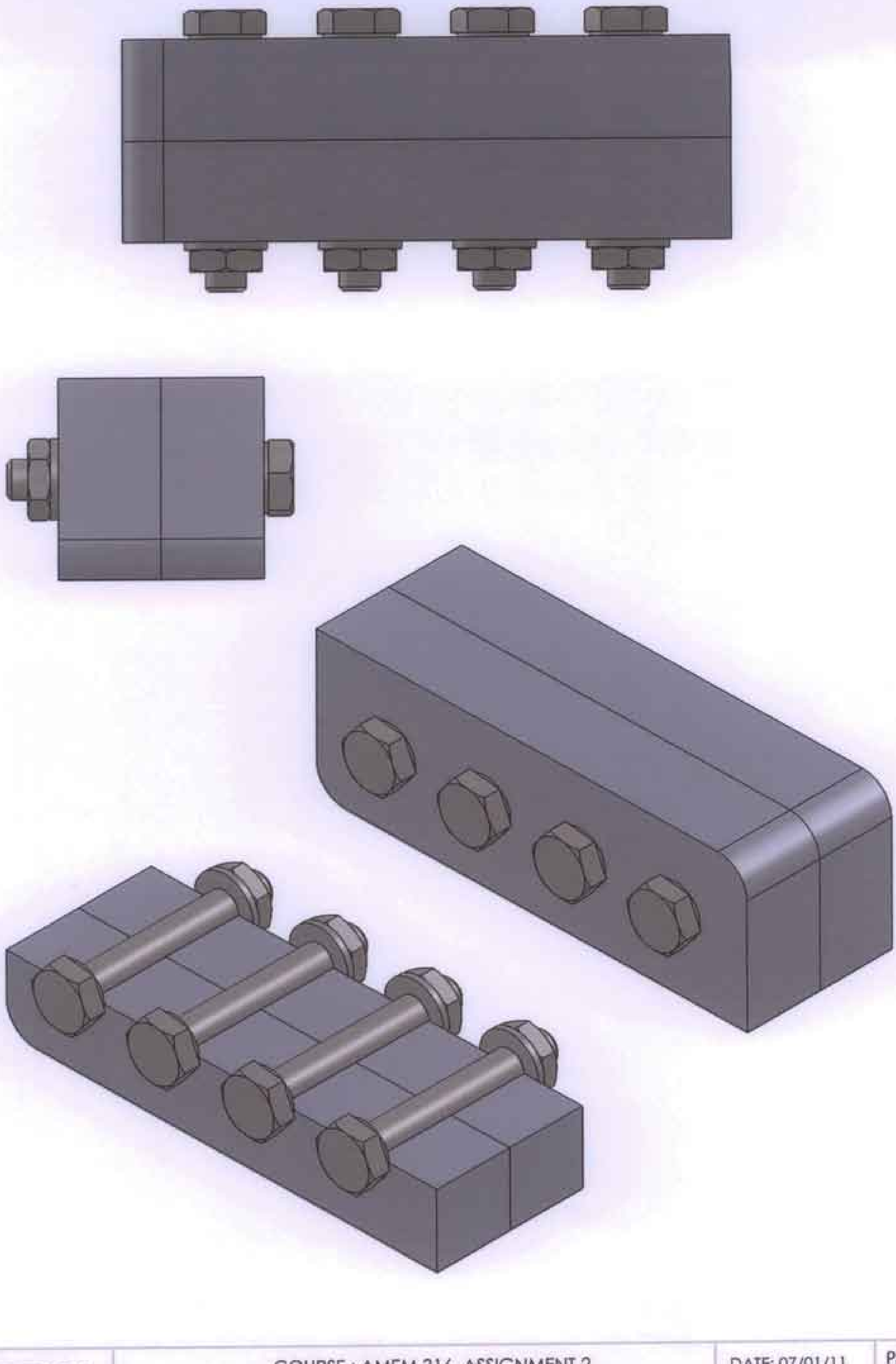
| | 1.FASTENERS | SCALE : 2:1 | 4 |



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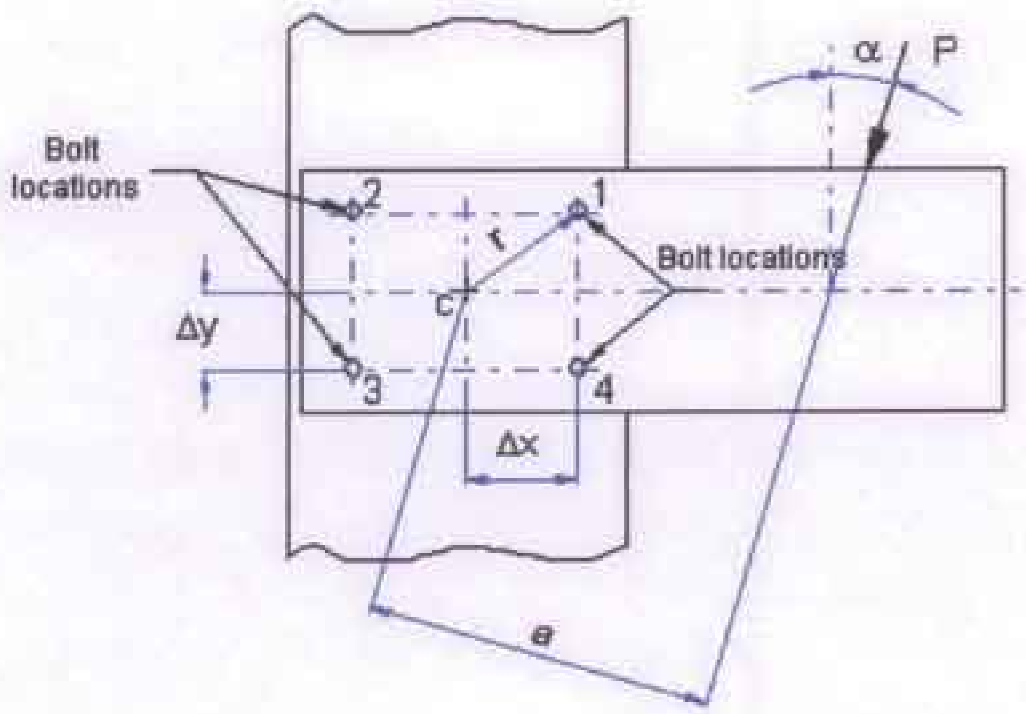
| | 1.FASTENERS | SCALE : 2:1 | 5 |

## 2. BOLTED CONNECTION

Geometry of bolted joint




### Input data:

| | | | |
|---|---|---|---|
| Bolt material type | = | A307 | |
| Allowable shear stress for bolt | σa = | 110 | MPa |
| Shear load | F2=P= | (b) 14973 | N |
| Number of bolts | N = | 4 | |
| Distance to the centroid | a = | 310 | mm |
| Radial distance for bolt(s) | r = | 144.2 | mm |
| x-distance from bolt to centroid | Δx = | 120 | mm |
| y-distance from bolt to centroid | Δy = | 80 | mm |
| Angle of inclination | α = | 45 | ° |

### Calculations:

**Load per bolt in x-direction**

$$F_{Sx} = \sin(a) * \frac{P}{N} = \sin(45) * \frac{14973}{4} = \sin(45) * 3743.25 = 2646.9N$$

**Load per bolt in y-direction**

$$F_{Sy} = \cos(a) * \frac{P}{N} = \cos(45) * \frac{14973}{4} = \cos(45) * 3743.25 = 2646.9N$$

**Moment to be resisted**

$$M = P * \mathrm{a} = 14973 * 310 = 4641630N * mm$$

**Force required to resist the bending moment**

$$F_i = F_1 = \frac{M * r_1}{N * r^2} = \frac{4641630 * 144.2}{4 * (144.2)^2} = \frac{699323046}{83174.56} = 8047.21N$$

**Total force in x-direction**

$$F_{tx} = F_{sx} + \sin(\theta) * F_1 = 2646.9 + \sin(45) * 8047.21 = 8337.14N$$

**Total force in y-direction**

$$F_{ty} = F_{sy} + \cos(\theta) * F_1 = 2646.9 + \cos(45) * 8047.21 = 8337.14N$$

**Resultant force on bolt**

$$R_s = \sqrt{F_{tx}^{\ 2} + F_{ty}^{\ 2}} = \sqrt{(8337.14)^2 + (8337.14)^2} = 11790.5N$$

**Required area for the bolt**

$$A_s = \frac{R_s}{\sigma_a} = \frac{11790.5}{110} = 107.19mm^2$$

**Required diameter**

$$A = A_s = \frac{\pi * D_r^2}{4} \rightarrow D_r^2 = \frac{4 * A}{\pi}$$

$$D_r = \sqrt{\frac{4 * A}{\pi}} = \sqrt{\frac{4 * 107.19}{\pi}} = \sqrt{\frac{428.76}{\pi}} = \sqrt{136.48} = 11.7mm$$

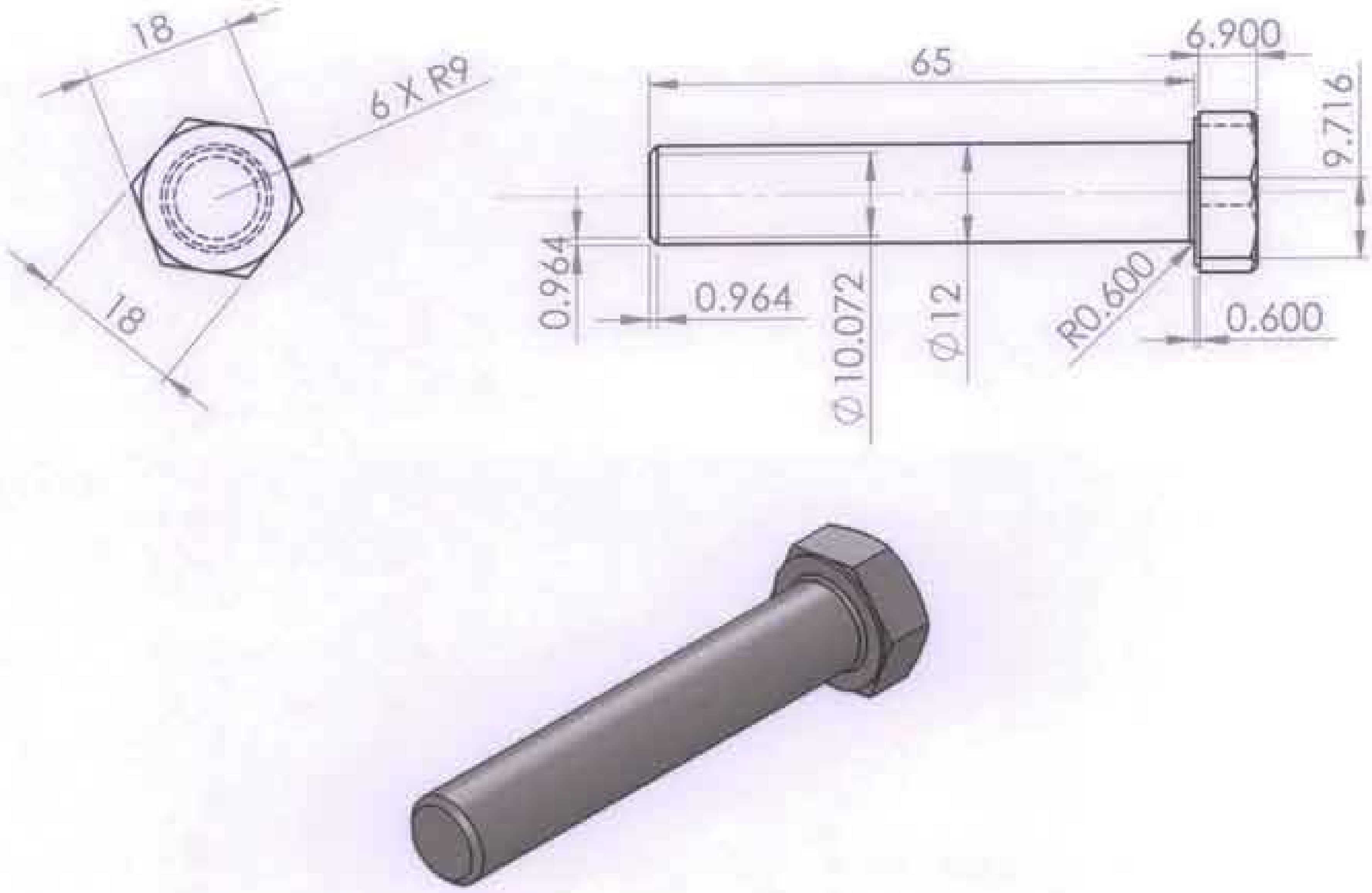
## Results:

| | | | | |
|---|---|---|---|---|
| Load per bolt in x-direction | Fsx | = | 2646.9 | N |
| Load per bolt in y-direction | Fsy | = | 2646.9 | N |
| Moment to be resisted | M | = | 4641630 | N*mm |
| Force required to resist the bending moment | Fi | = | 8047.21 | N |
| Total force in x-direction | Ftx | = | 8337.14 | N |
| Total force in y-direction | Fty | = | 8337.14 | N |
| Required area for the bolt | As | = | 107.19 | $mm^2$ |
| Required diameter | Dr | = | 11.7 | mm |
| Resultant force on bolt | Rs | = | 11790.5 | N |
| Nearest standart bolt diameter | D | = | 12=M12 | mm |

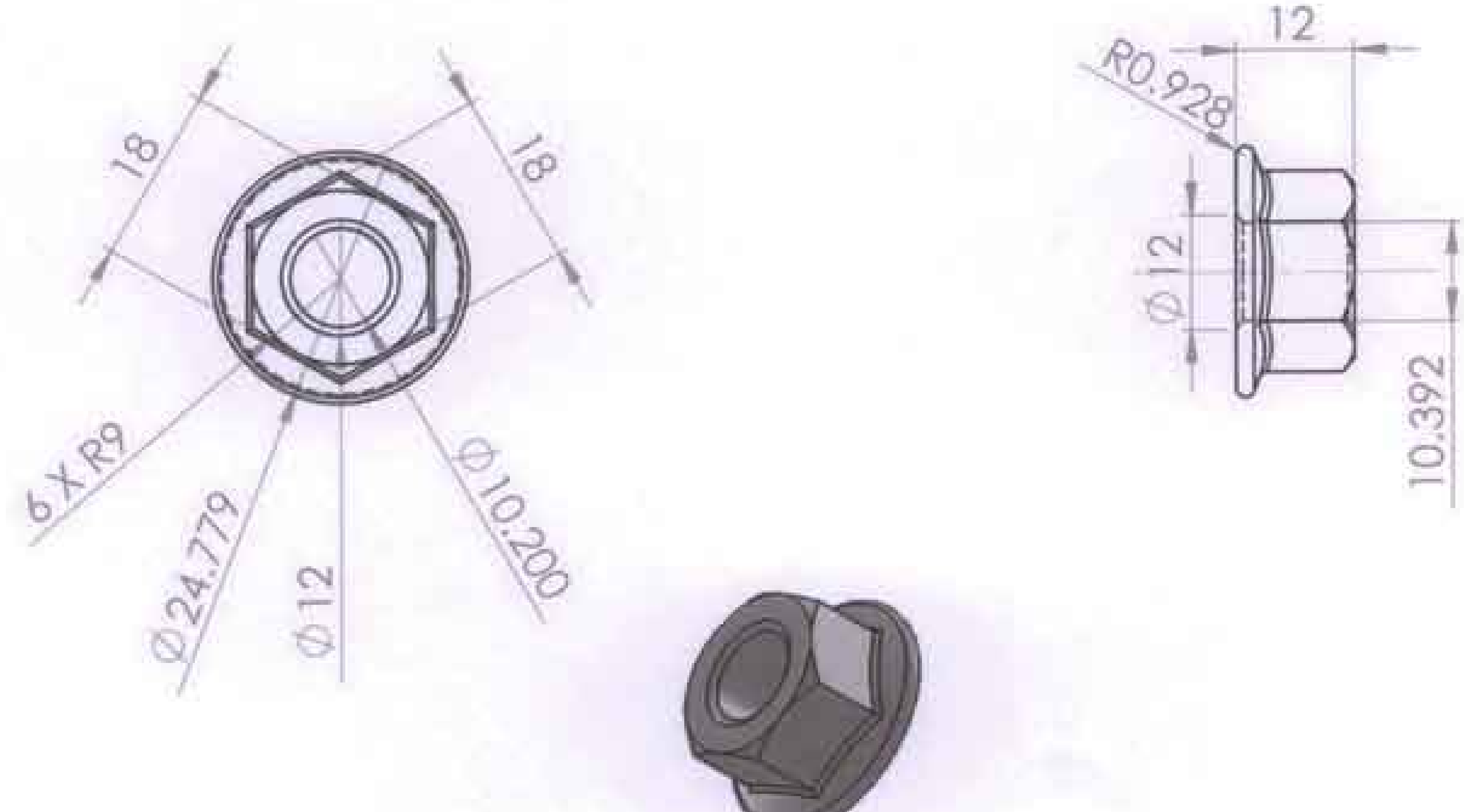
**Nearest standart bolt diameter**

Finally I chose bolt diameter =12=M12 for more safety and it is a standard bold diameter.

## HEX BOLT GRADE AB-ISO (ISO 4014-M12X65X30-C)




## HEX FLANGE NUT GRADE AB
## (HEXAGON FLANGE NUT ISO 4161-M12-C)

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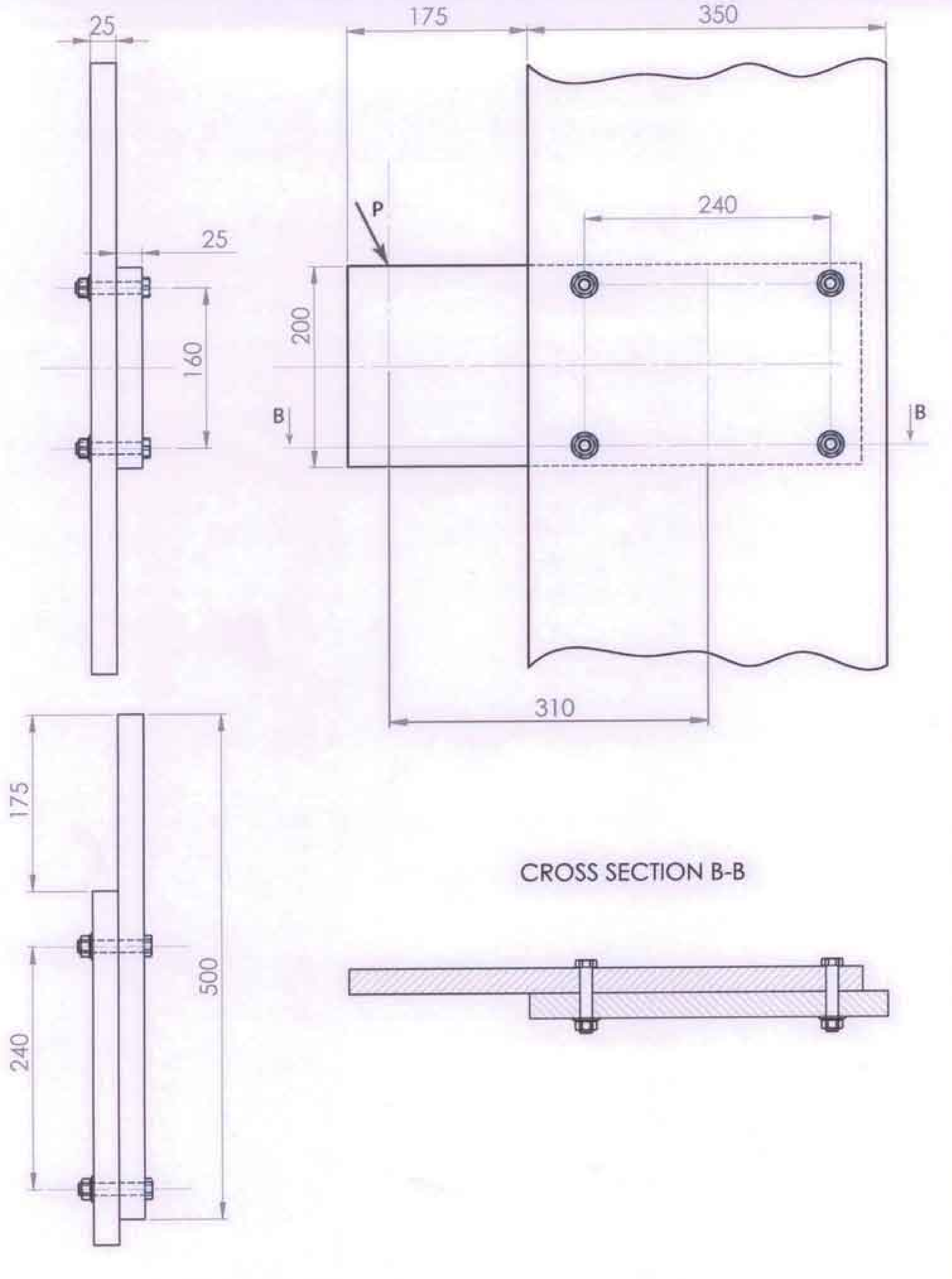
| | 2.BOLTED CONNECTION | SCALE : 1:1 | 10 |

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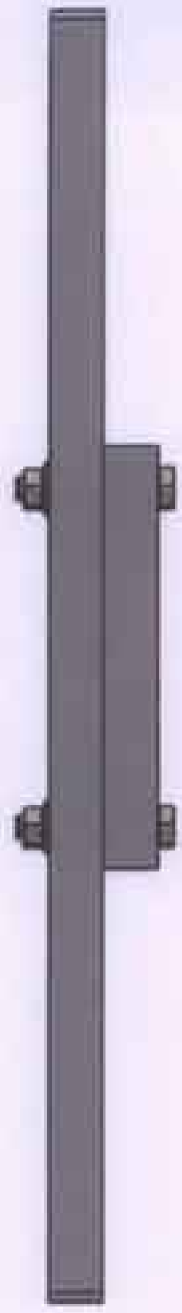
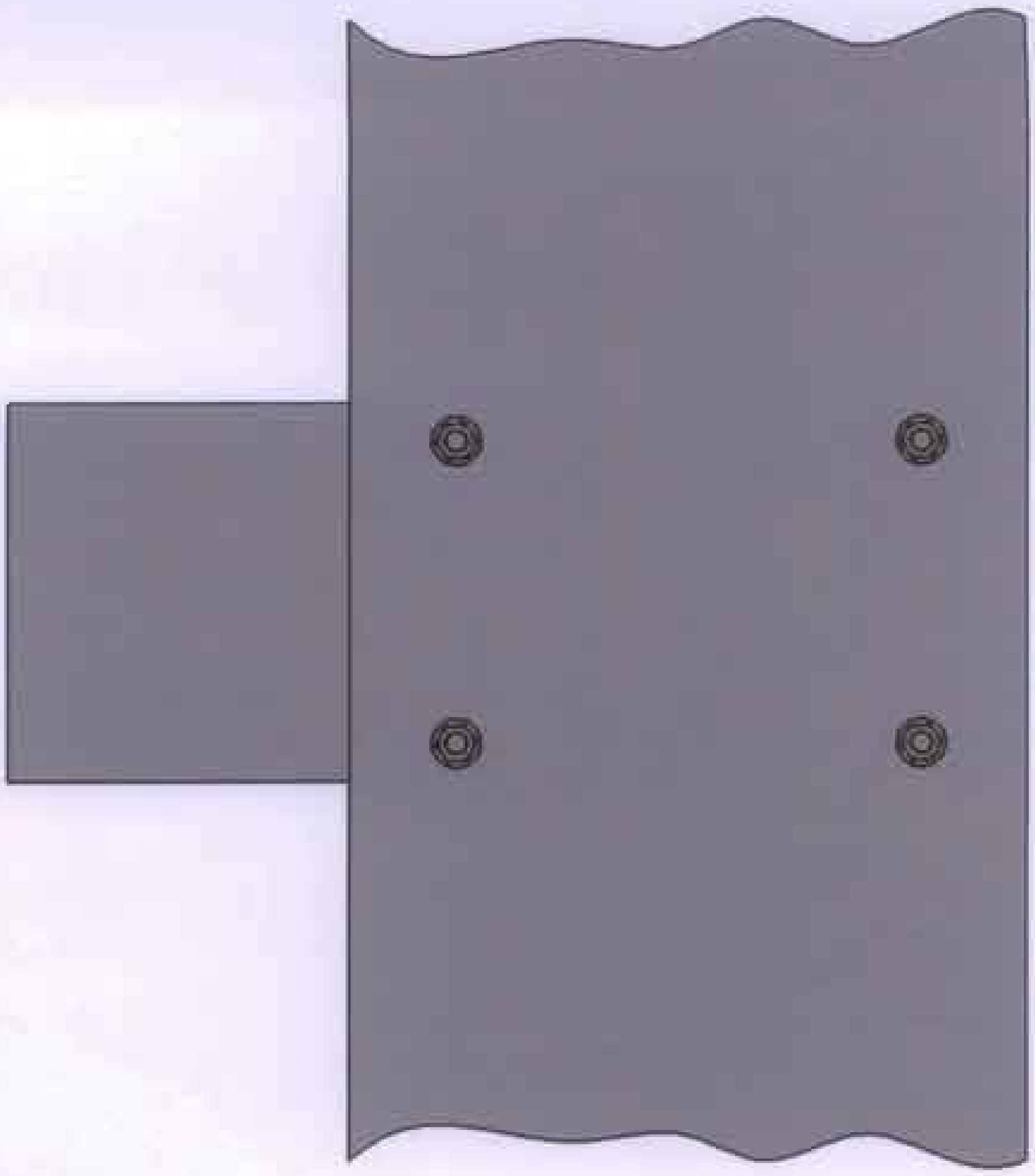
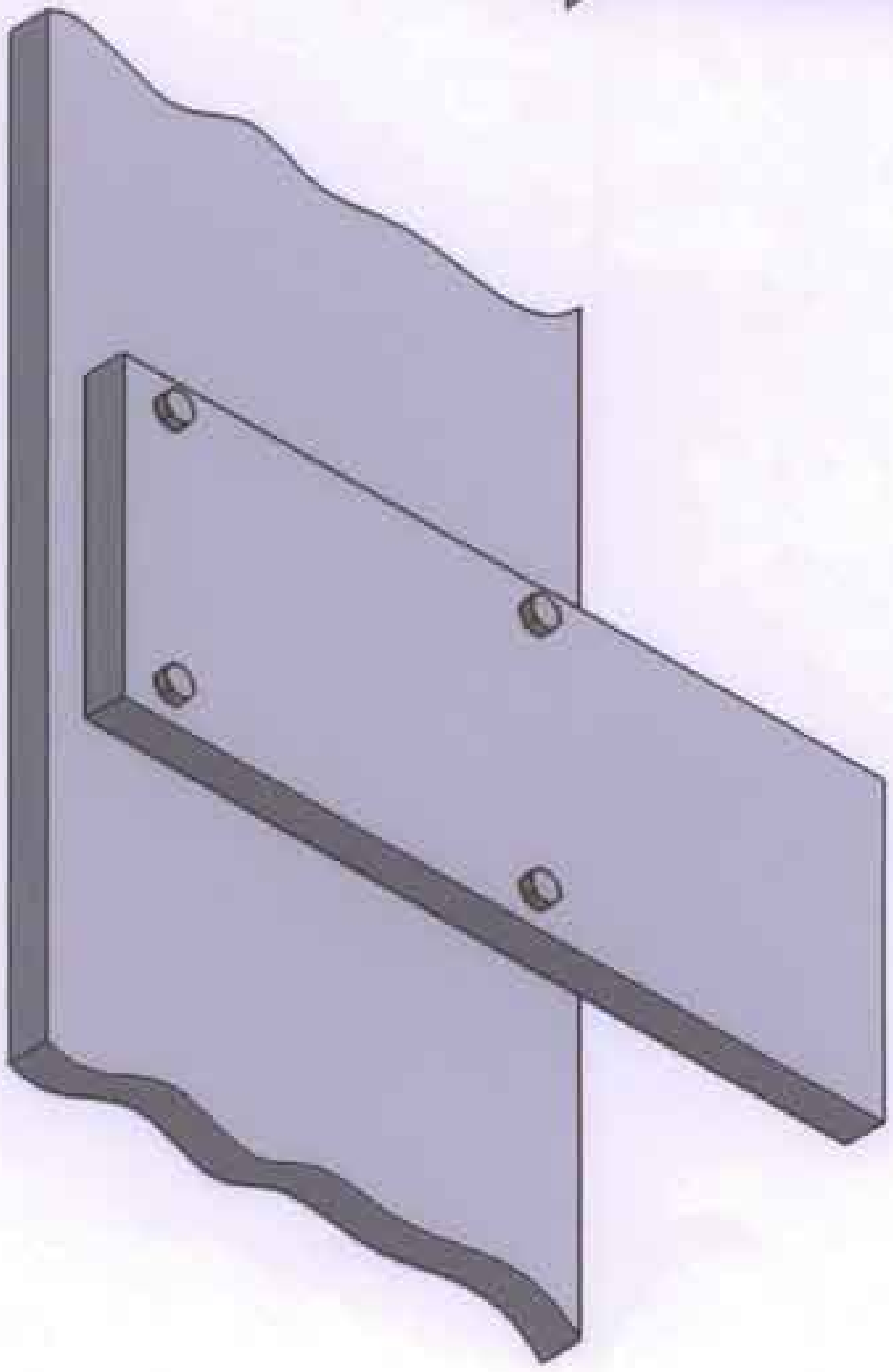
| | 2.BOLTED CONNECTION | SCALE : 1: 5 | 11 |







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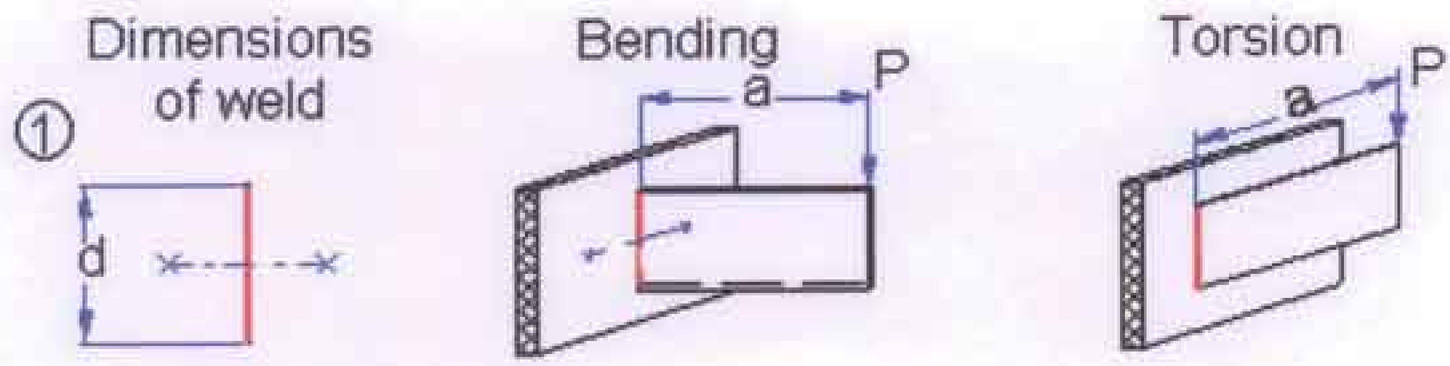
| | 2.BOLTED CONNECTION | SCALE : 1:5 | 12 |

# 3. WELDED JOINTS




## Input data:

| | | | |
|---|---|---|---|
| Type of connection | Type 1 | | |
| | | | |
| Geometry Factors of the Connection | | | |
| Length in y-axis | d = | 130 | mm |
| Bending console length | $a_b$ = | 80 | mm |
| Twisting console length | $a_t$ = | 160 | mm |
| | | | |
| Load | F3=P= | (c) 6552 | N |
| | | | |
| Allowable force per inch of leg | Fallow = | 2100 | N/mm |

## Calculations:

**Distance to the centroid in y-axis**

$$y = \frac{d}{2} = \frac{130}{2} = 65mm$$

**Geometry factors:**

**Length of weld**

$$A_w = d = 130mm$$

**Unit area moment of inertia**

$$S_w = \frac{d^2}{6} = \frac{130^2}{6} = 2816.67mm^2$$

**Unit polar area moment of inertia**

$$J_w = \frac{d^3}{12} = \frac{130^3}{12} = \frac{2197000}{12} = 183083.3mm^3$$

**Bending moment**

$$M = P*(a_b) = 6552*80 = 524160N*mm$$

**Twisting moment**

$$T = P*(a_t) = 6552*160 = 1048320 N*mm$$

**Twisting force**

$$F_t = \frac{T*y}{J_w} = \frac{1048320*65}{183083.3} = \frac{68140800}{183083.3} = 372.2 N/mm$$

**Bending force**

$$F_b = \frac{M}{S_w} = \frac{524160}{2816.67} = 186.1 N/mm$$

**Vertical shear force**

$$F_s = \frac{P}{A_w} = \frac{6552}{130} = 50.4 N/mm$$

**Resultant of the force components**

$$F_r = \sqrt{F_b^2 + F_s^2} = \sqrt{(186.1)^2 + (50.4)^2} = 192.8 N/mm$$

**Required weld leg size (Fr/Fallow)**

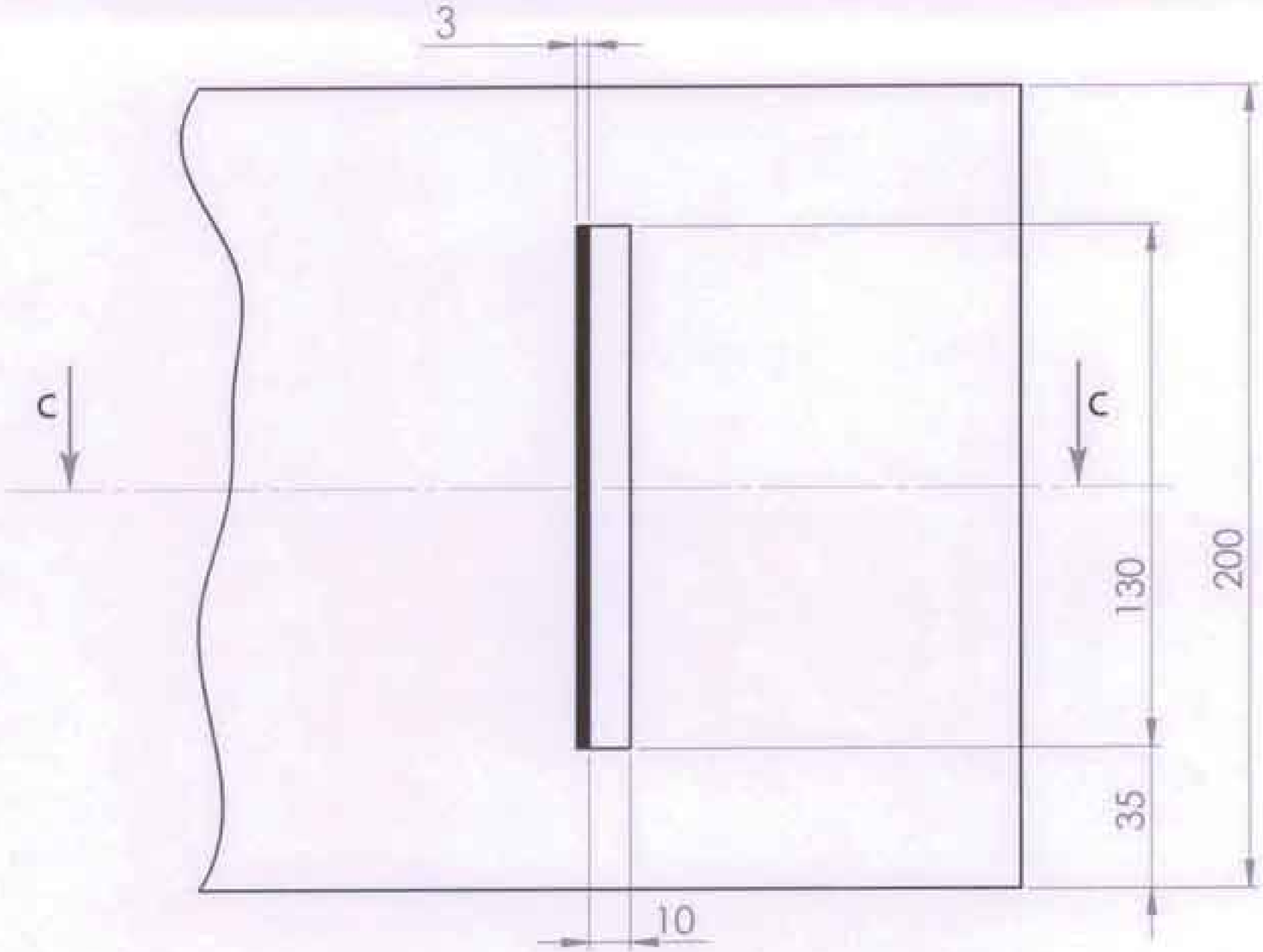
$$W = \frac{F_r}{F_{allow}}*25.4 = \frac{192.8}{2100}*25.4 = 0.092*25.4 = 2.33mm$$

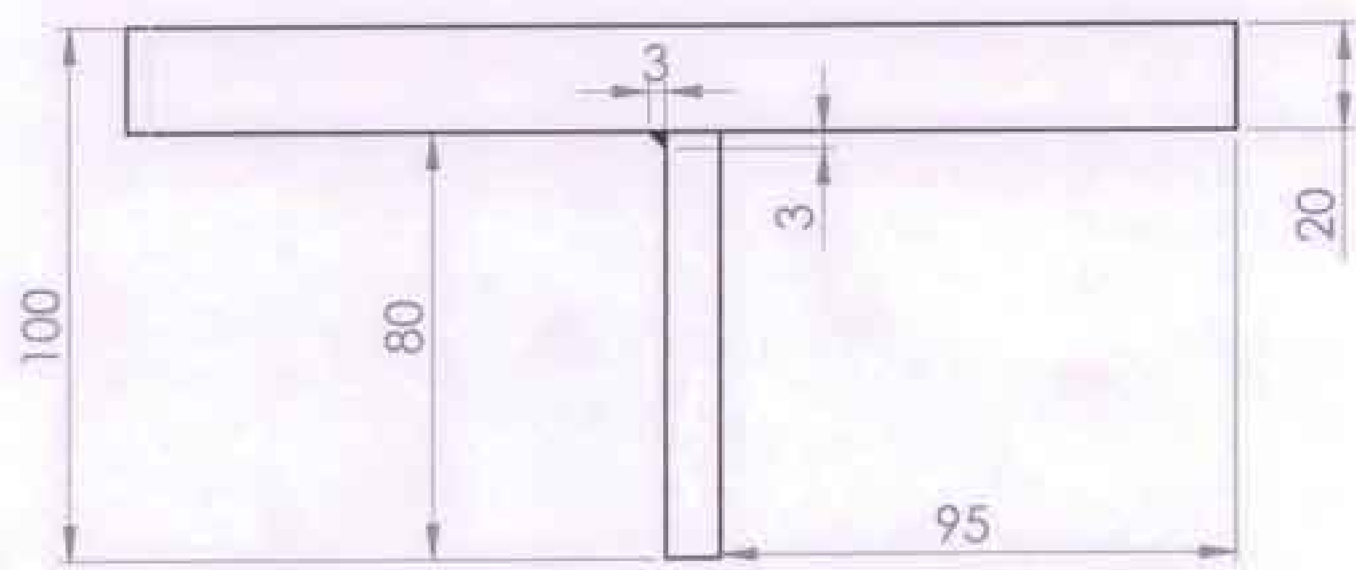
## Results

| | | | |
|---|---|---|---|
| Distance to the centroid in y-axis | y= | 65 | mm |
| Geometry factors: | | | |
| Length of weld (m) | Aw= | 130 | mm |
| Unit area moment of inertia ($m^2$) | Sw= | 2816.67 | $mm^2$ |
| Unit polar area moment of inertia ($m^3$) | Jw= | 183083.3 | $mm^3$ |
| | | | |
| Bending moment | M= | 524160 | N*mm |
| Twisting moment | T= | 1048320 | N*mm |
| | | | |
| Twisting force | Ft= | 372.2 | N/mm |
| | | | |
| Bending force | Fb= | 186.1 | N/mm |
| Vertical shear force | Fs= | 50.4 | N/mm |
| | | | |
| Resultant of the force components | Fr= | 192.8 | N/mm |
| Required weld leg size (Fr/Fallow) | w= | 2.33→3 | mm |

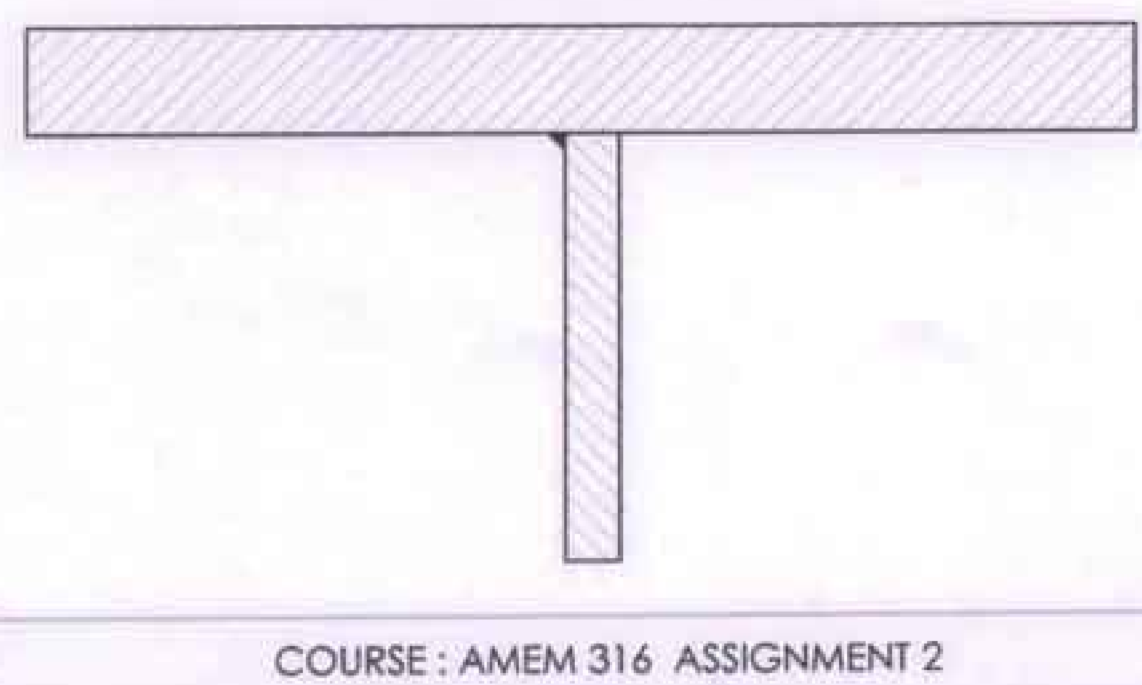
Finally i chose weld leg size w=3mm for more safety .

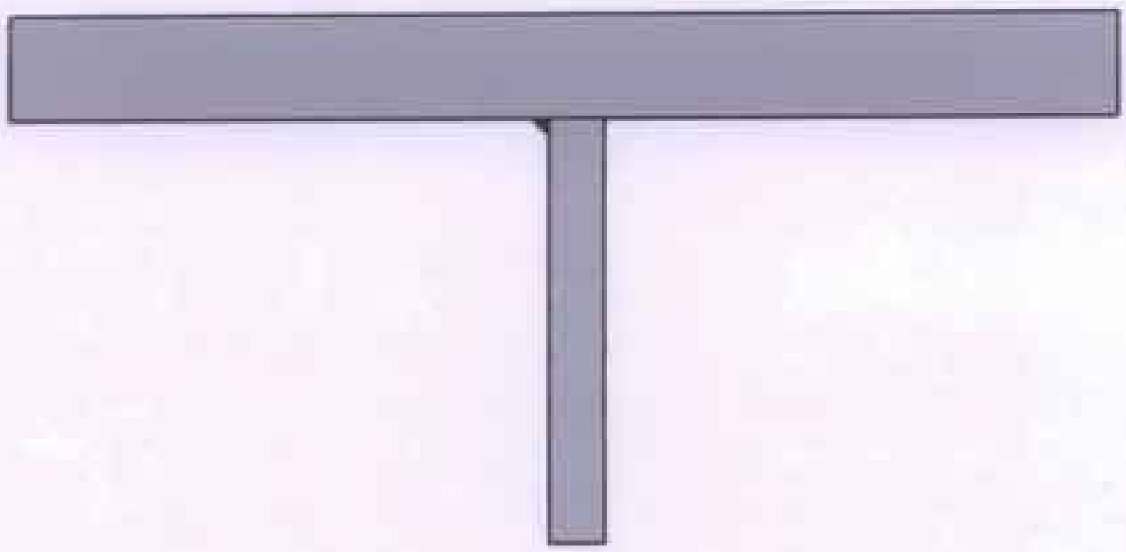
# TYPE 1 : BENDING

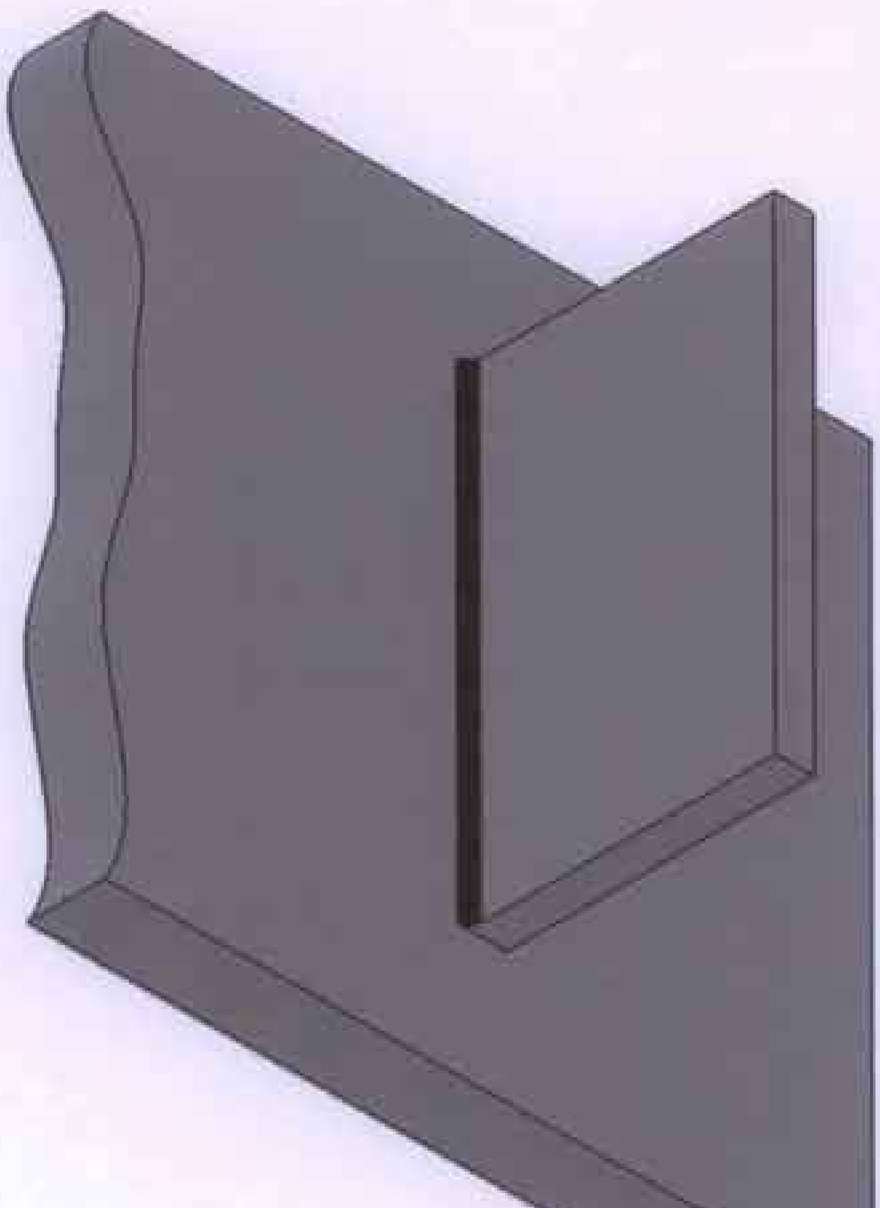



## CROSS SECTION C-C







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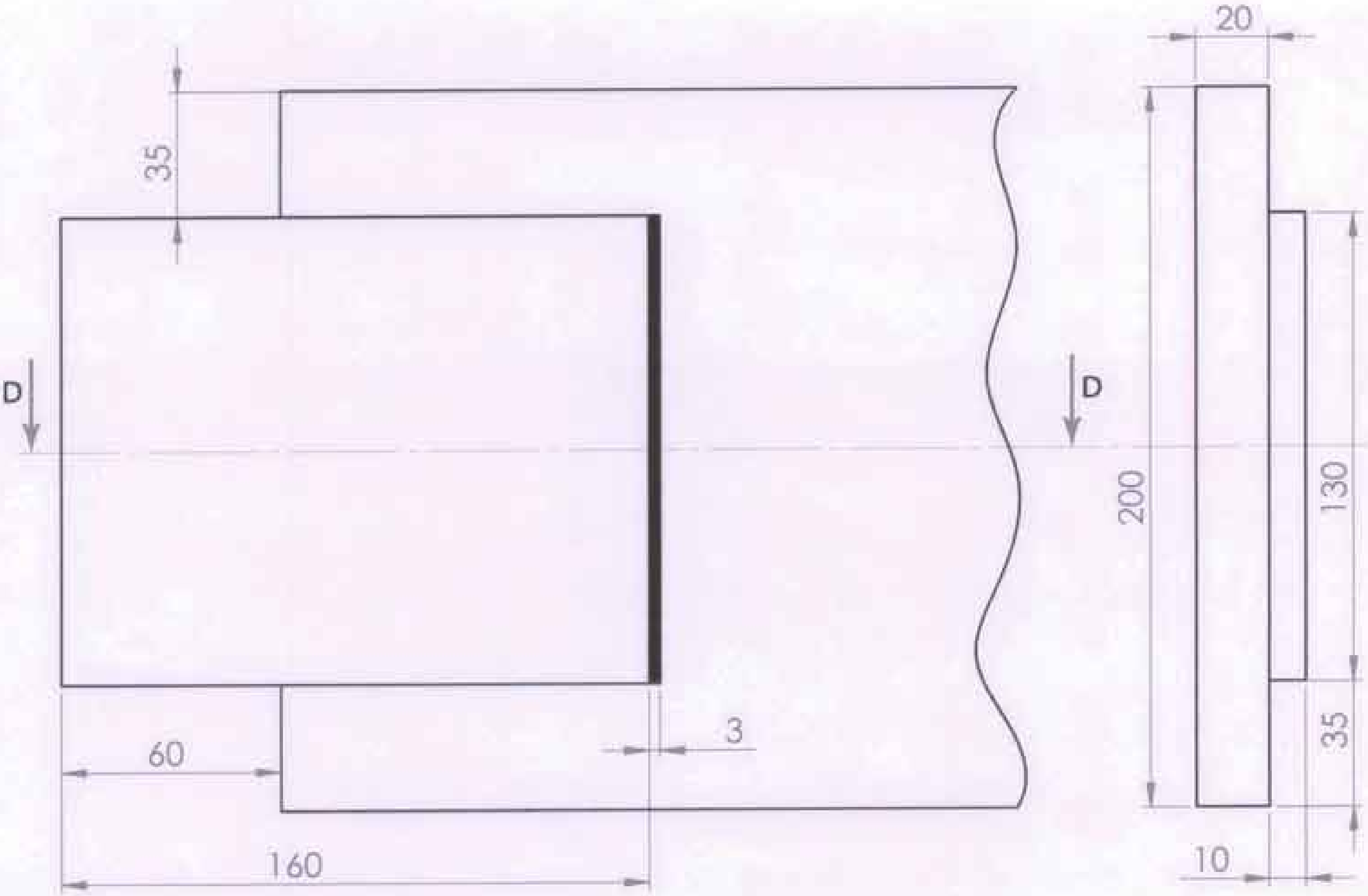
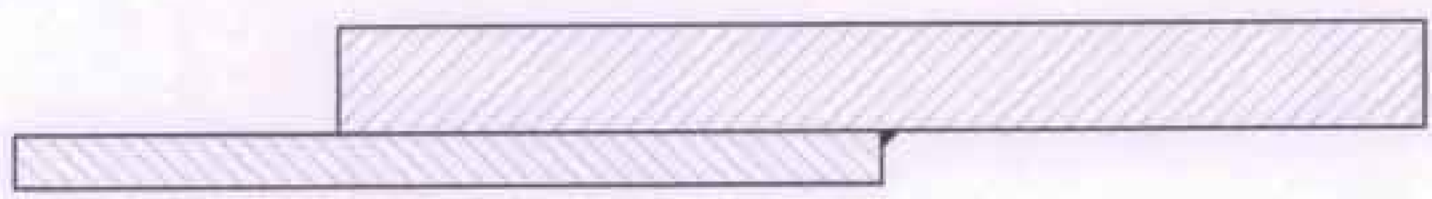
| | 3.WELDED JOINTS | SCALE : 1:2 | 17 |

TYPE 1 : TORSION




CROSS SECTION D-D



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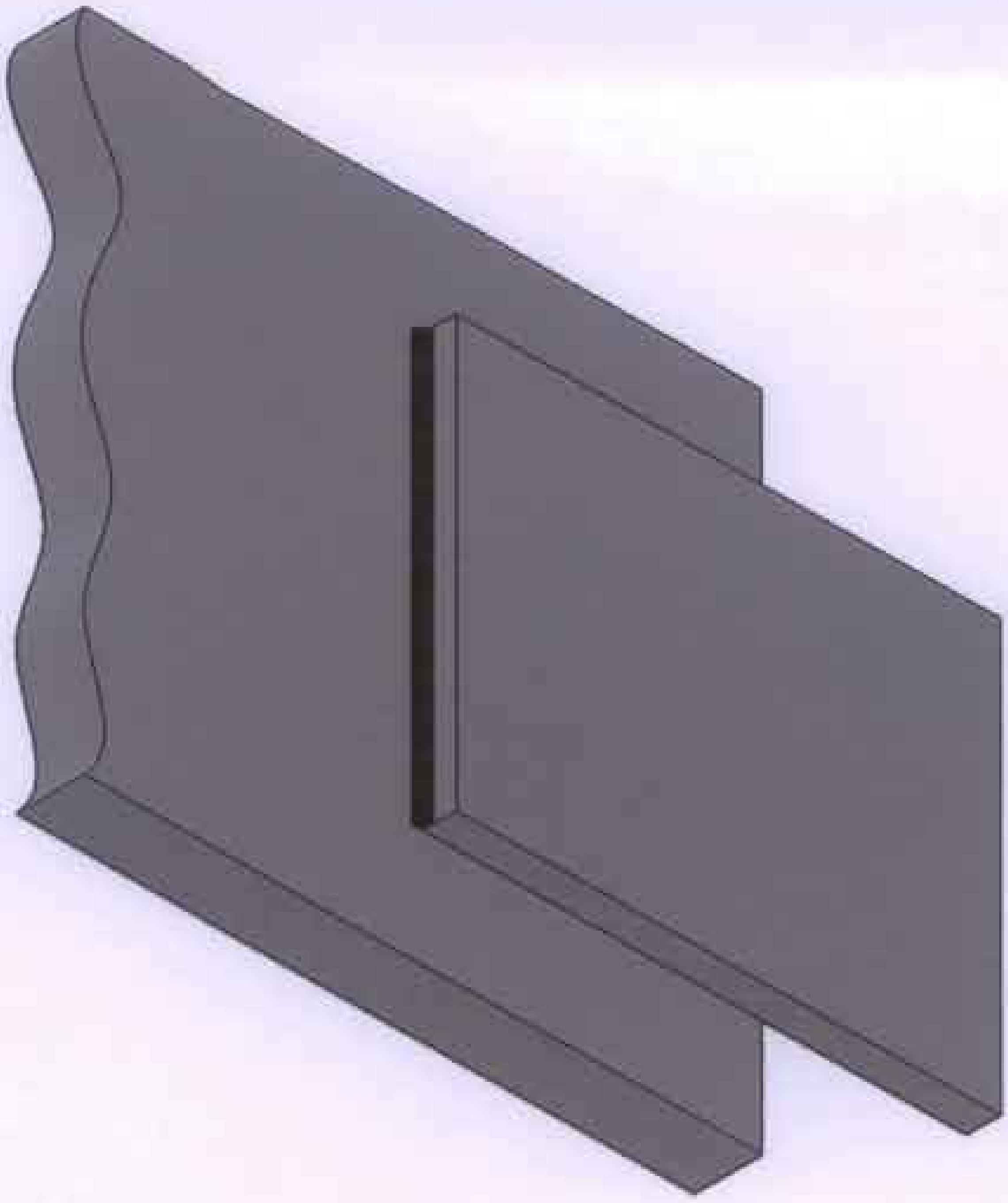

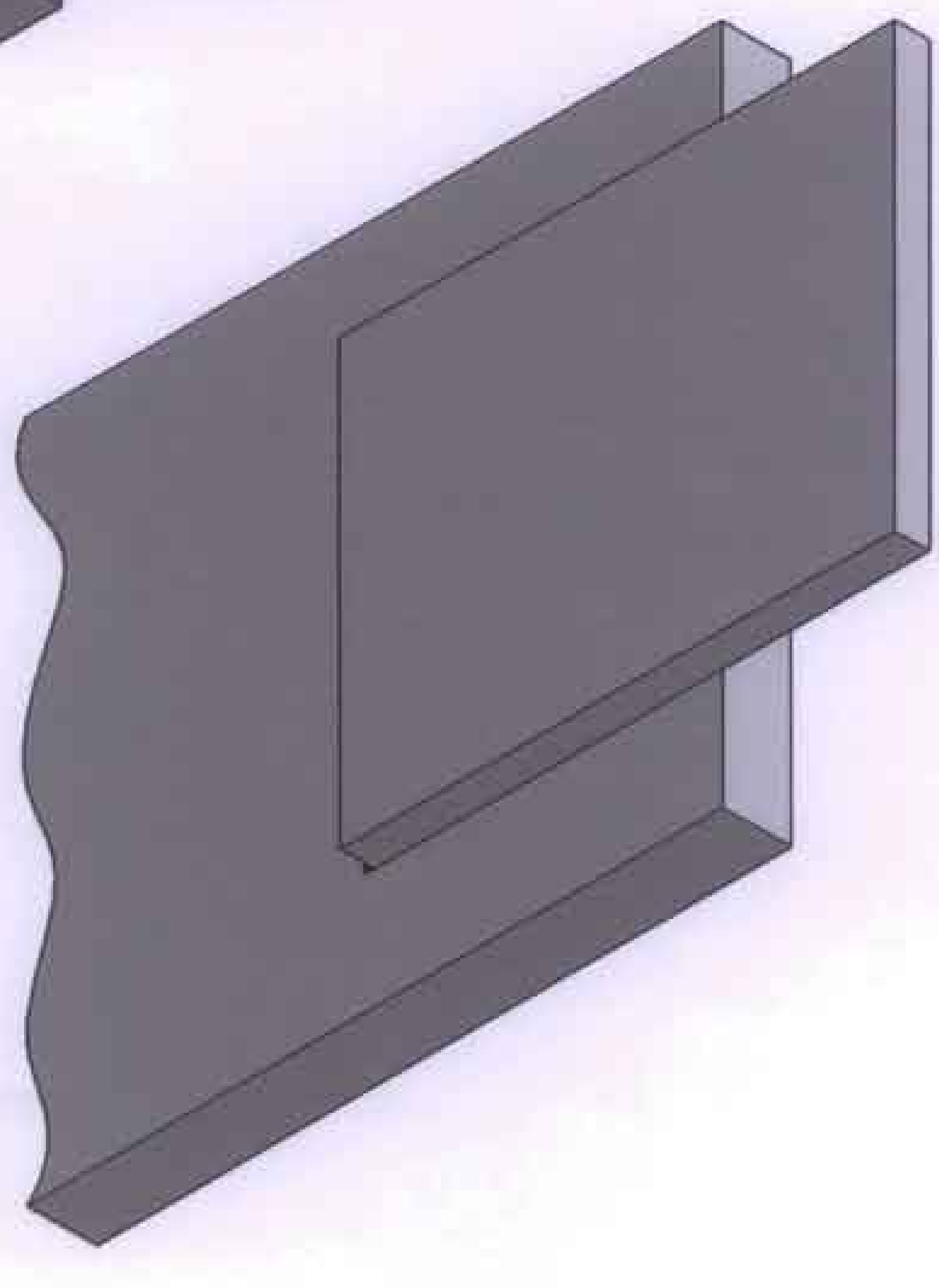

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## Websites :

http://www.nutsandbolts.com


Elevator Bolts Zinc


Flange Bolts Grade 8


Flat Socket Cap Screws Coarse


Hex Head Cap Screws-Bolts Grade 5 Coarse


Hex Head Cap Screws-Bolts Grade 8 Coarse


Hex Head Cap Screws-Bolts Grade 8 Fine


Lag Bolts - Hex Zinc


Metric Flange Bolts - JIS


Metric Hex Bolts-Cap Screw 8.8


Flange Nuts Locking Grade G USS Yel


Serrated Hex Flange Lock Nuts - Coarse Thread - Grade 2 - Zinc

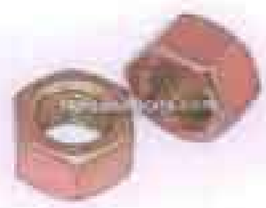

Serrated Hex Flange Lock Nuts - Fine Thread - Grade 2 - Zinc


Heavy Hex Nuts Grade 2


Heavy Hex Nuts Grade 5


Hex Nuts Grade 5 Coarse Plain


Hex Nuts Grade 5 Coarse Zinc


Hex Nuts Grade 8 Coarse


Hex Nuts Grade 8 Fine

## Websites :

http://www.msadaqatcorp.com/

http://www.msadaqatcorp.com/

## Websites :

http://web.mst.edu/~ide110-1/lessons/01/shear/index.html

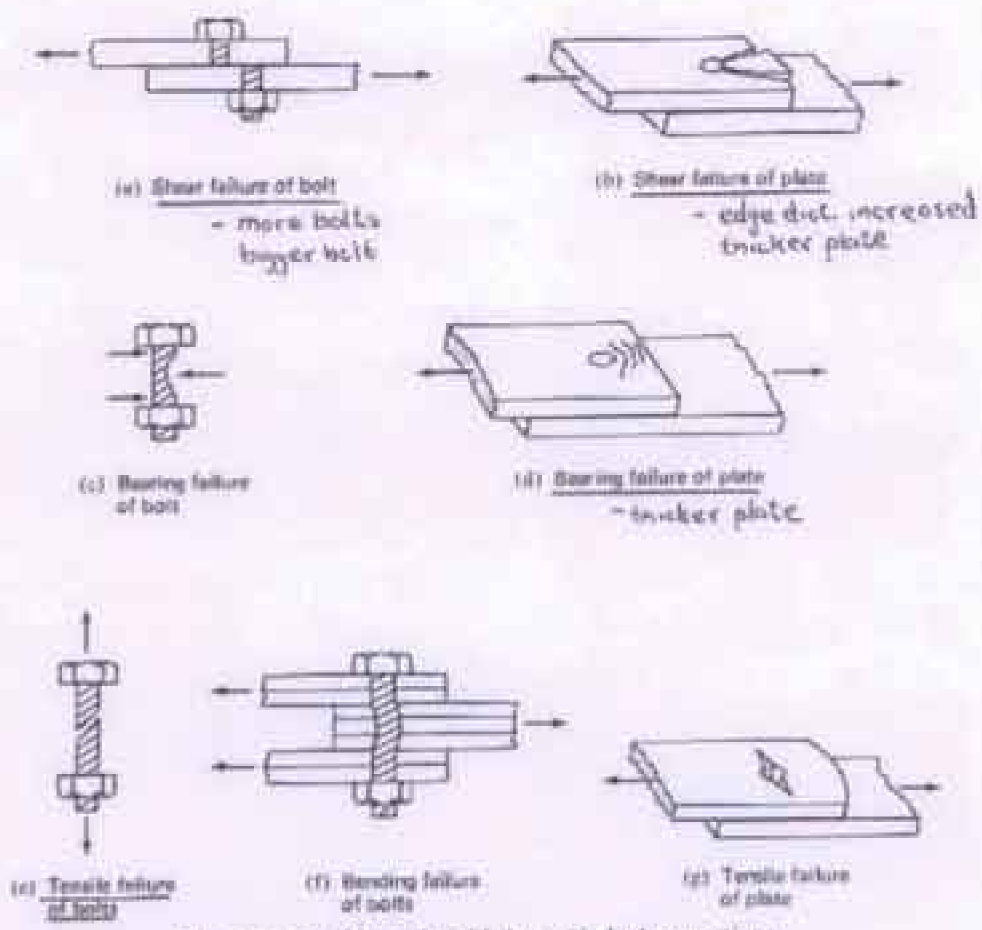
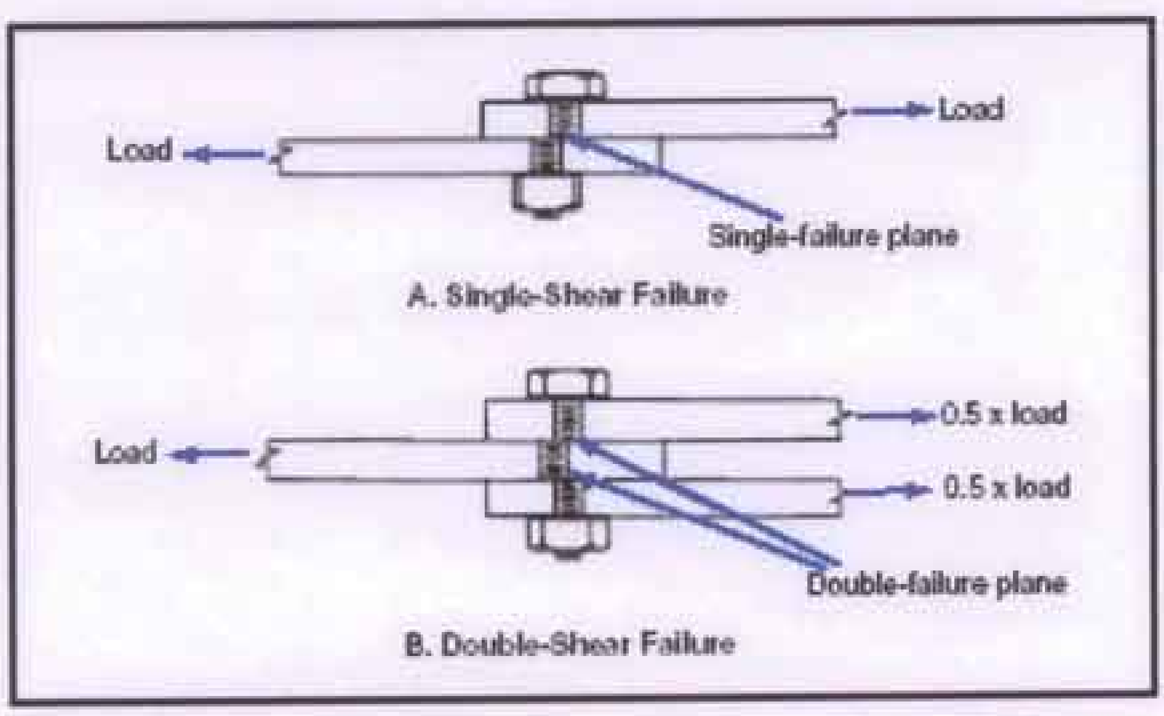



Fig. 4.5.2. Possible modes of failure of bolted connections.

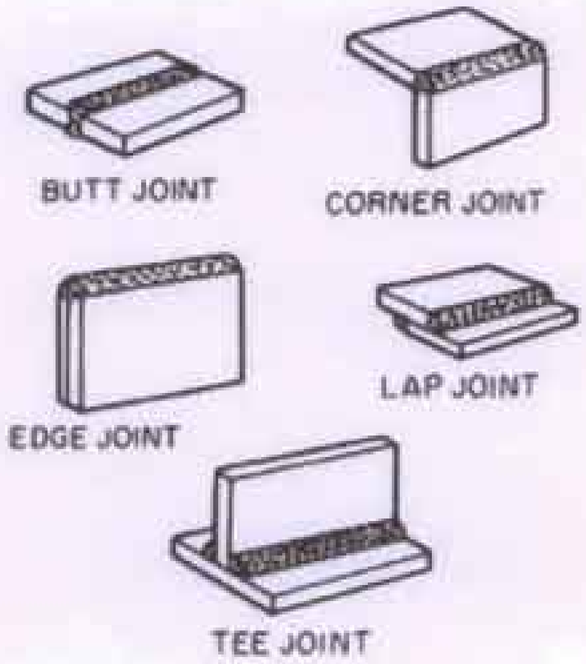
Steel Stuctures - Design and Behavior
by C.G. Salmon and J.E. Johnson
Intext Educational Publishers, 1971, p. 97

http://www.globalsecurity.org/military/library/policy/army/fm/3



## Websites :

http://www.answers.com/topic/welded-joint




http://www.laserbeamweld.com/Laser Welding.html